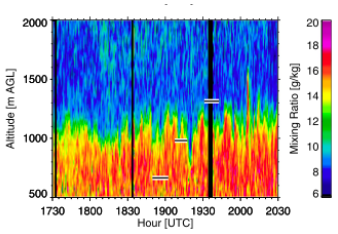
Validating Water Vapor Turbulence Measurements from Lidar

Research Highlight

Turbulence in the convective boundary layer is important for redistributing water vapor and other atmospheric gases, sensible heat, and momentum. Turbulent mixing works over a wide range of scales from kilometers down to millimeters. The horizontal and vertical resolutions of most atmospheric models, such as general circulation and cloud resolving models, are too coarse to capture turbulent motions directly, and thus boundary layer turbulence is parameterized in these models. These parameterizations must be able to accurately represent the higher-order fluctuations in water vapor, wind, and temperature as a function of height.

The ARM program has deployed several lidar systems that are able to measure geophysical variables at high temporal and vertical resolution. Wulfmeyer et al. (2010) demonstrated that the ARM Raman lidar has the sensitivity to resolve the second and third moment of the water vapor mixing ratio profile, and hence the water vapor skewness profile, in the convective boundary layer. An autocovariance technique was used to separate out the random instrument error from the atmospheric variability. Turner et al. (2014) used airborne water vapor observations from the Routine AAF Clouds with Low Optical Water Depths (CLOWD) Optical Radiative Observations (RACORO) field experiment in 2009 to demonstrate, for the first time, that this autocovariance technique accurately determined the atmospheric variance and skewness from the noisy Raman lidar water vapor observations.

While the Turner et al. study only investigated two cases, it paves the way for a more detailed long-term analysis of the Raman lidar water vapor observations.



Time-height cross-section of water vapor mixing ratio observed by the Raman lidar on 15 June 2009 at the SGP site. The turbulent mixing is easily seen by the plumes of water vapor (red/orange) extending from the convective boundary layer (CBL) into the drier free troposphere, and the dry air being entrained into the CBL. The aircraft flight legs are shown as horizontal bars on the figure.

Reference(s)

Turner DD, RA Ferrare, V Wulfmeyer, and AJ Scarino. 2014. "Aircraft evaluation of ground-based Raman lidar water vapor turbulence profiles in convective mixed layers." Journal of Atmospheric and Oceanic Technology, 31, 10.1175/JTECH-D-13-00075-1.

Wulfmeyer V, S Pal, DD Turner, and E Wagner. 2010. "Can water vapour raman lidar resolve profiles of turbulent variables in the convective boundary layer?" Boundary-Layer Meteorology, 136(2), doi:10.1007/s10546-010-9494-z.

Contributors

David D. Turner, *National Oceanic and Atmospheric Administration*

Working Group(s)

Cloud Life Cycle